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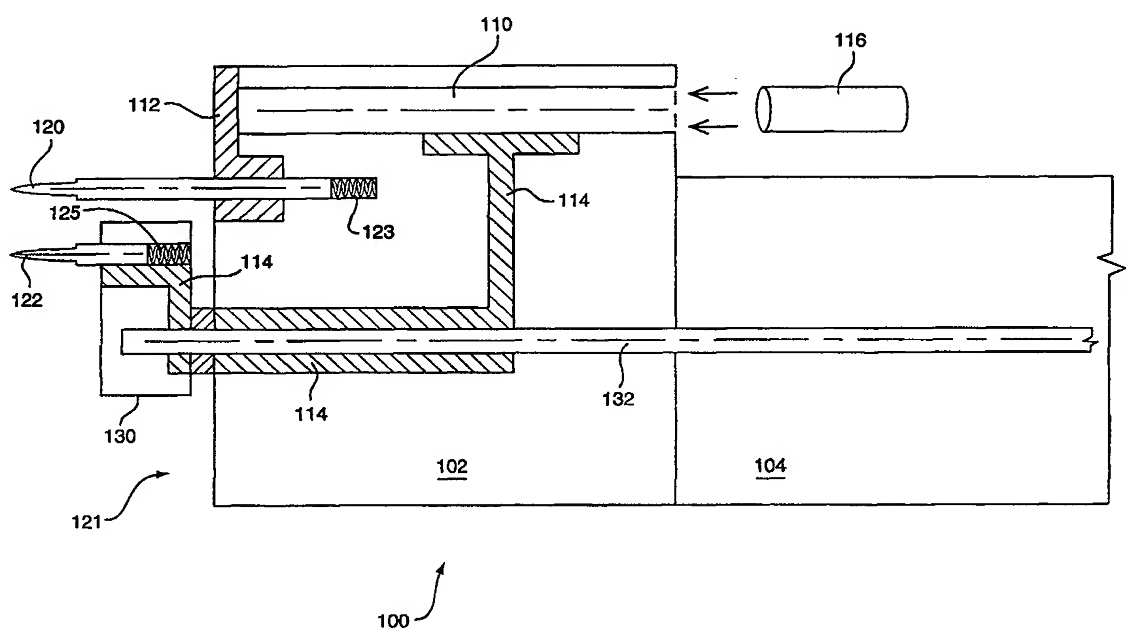

(57) Abstract

A dual–pin probe (100) has a probe body (104), a probe head (102), a signal pin (120), and a ground pin (122). The probe body couples to a robotic system configured to manipulate the dual–pin probe relative to a circuit board under test. The probe body is coupled to the probe head. The signal pin and the ground pin extend from a face of the probe head and are substantially parallel to one another. The ground pin is at a variable distance from the signal pin. The robotic system varies the distance between the ground pin and the signal pin, and positions the ground pin and the signal pin to contact nodes on the circuit board to automate the test.

DUAL-PIN PROBE FOR TESTING CIRCUIT BOARDS

Background of the Invention

1. Field of the Invention

The invention relates to the field of testing devices, and in particular, to a dual-pin probe for circuit board testing.

2. Statement of the Problem

Manufacturers of circuit boards generally test the circuit boards coming off of an assembly line to ensure proper performance and quality. Consequently, the time and cost of manufacturing the circuit boards include the time and cost of testing the circuit boards. Manufacturers try to lower the time and cost of testing without degrading the quality of the circuit boards.

A current testing method involves manually testing signals at various nodes on the circuit boards. The test equipment used is generally a conventional oscilloscope or a test probe. The conventional test probe has a signal lead and a ground lead. For manual circuit board testing, a tester touches the ground lead to a ground node on the circuit board. The tester touches the signal lead to a signal node that carries the signal to be tested. The tester records and verifies data read from the test probe.

One problem with the current testing method is speed. As the circuit boards become more densely populated with components, the number of nodes to be tested increases. The manual testing is slow, and testing many nodes manually increases the testing time and manufacturing costs of the circuit board. Another problem with the current testing method is precision. Manual testing brings in the possibility of human error. As the components on the circuit board move closer together, the chance of manual testing errors increases. Test errors could occur by probing the wrong node, or probing two nodes at the same time by mistake. Test errors could also occur by simply mis-recording the test data.

Summary of the Solution

The invention solves the above problems by automating the circuit board testing using a dual-pin probe. The dual-pin probe has a probe body, a probe

head, a signal pin, and a ground pin. The probe body couples to a robotic system configured to manipulate the dual-pin probe relative to a circuit board under test. The probe body is coupled to the probe head. The signal pin and the ground pin extend from a face of the probe head and are substantially parallel to one another. The ground pin is at a variable distance from the signal pin. The robotic system varies the distance between the ground pin and the signal pin, and positions the ground pin and the signal pin to contact nodes on the circuit board to automate the test.

The dual-pin probe of the invention automates circuit board testing which is an advance in the art. The dual-pin probe improves the reliability of circuit board testing because of extreme precision. The dual-pin probe reduces the manufacturing cost by reducing the testing time.

Description of the Drawings

FIG. 1 shows a first embodiment of a dual-pin probe constructed according to the invention;

FIG. 2 illustrates the dual-pin probe of FIG. 1 coupled to a robot interface;

FIG. 3 shows another embodiment of a dual-pin probe according to the invention;

FIG. 4 shows the dual-pin probe of FIG. 3 coupled to a robot interface.

Detailed Description of the Invention

Dual-pin probe -- FIGS. 1-2

FIGS. 1-2 depict a first embodiment of a dual-pin probe 100 in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features could be combined to form multiple variations of the invention.

The dual-pin probe 100 has a probe body 104, a probe head 102, a signal pin 120, a ground pin 122, a pivot arm 130, and a pivot 132. The probe body 104 connects to a robot interface (not shown) of a robotic system (not shown), the robotic system configured to manipulate the dual-pin probe 100. The probe head 102 connects to the probe body 104, and includes a contact tube 110, a signal

connection 112, and a ground connection 114. The probe head 102 is insulated to prevent short circuits. The contact tube 110 is configured to hold an electronics test probe, such as an active, passive, or logic probe. The contact tube 110 size is preferably flexible to accommodate different size test probes. Inside the contact tube 110, the signal connection 112 connects with a signal lead of the test probe. The signal connection 112 is for example a gold plated connection. The ground connection 114 connects with a ground lead of the test probe. The ground connection 114 is for example a gold plated connection.

The signal pin 120 mounts onto the probe head 102 and protrudes perpendicularly from a face 121 of the probe head 102. The signal pin 120 is for example made from a gold plated material. The signal pin 120 is preferably mounted on a spring 123 with a retraction of about 0.157 inches at a maximum. The signal pin 120 connects to the signal connection 112, creating a direct connection from the signal pin 120 to the signal lead of the test probe.

The pivot 132 extends from the probe body 104 through the probe head 102 to protrude perpendicularly to the face 121 of the probe head 102. The pivot arm 130 mounts on the pivot 132 and is substantially parallel to the face 121 of the probe head 102. The pivot 132 is configured to rotate clockwise or counter-clockwise which in turn rotates the pivot arm 130 in a 360 degree angle. The ground pin 122 mounts onto the pivot arm 130 and protrudes perpendicularly from the pivot arm 130 so that the ground pin 122 and the signal pin 120 are aligned substantially parallel to each other. The ground pin 122 is for example made from a gold plated material. The ground pin 122 is preferably mounted on a spring 125 with a retraction of about 0.157 inches at a maximum. The ground pin 122 connects to the ground connection 114 creating a direct connection from the ground pin 122 to the ground lead of the test probe. The signal pin 120 and the ground pin 122 are preferably fixed in length to ensure that minimal inductance is introduced into measured signals.

In operation, a test probe mounts inside an insulated connector 116. The insulated connector 116 and the test probe are inserted into the contact tube 110. The insulated connector 116 holds the test probe inside of the contact tube 110. The robotic system positions the dual-pin probe 100 over a circuit board so that the face 121 of the probe head 102 is substantially parallel to the circuit board. The

robotic system adjusts the linear distance between the signal pin 120 and the ground pin 122 by rotating the pivot arm 130. The robotic system increases the distance between the signal pin 120 and the ground pin 122 by rotating the pivot arm 130 away from the signal pin 120. The robotic system decreases the distance between the signal pin 120 and the ground pin 122 by rotating the pivot arm 130 toward the signal pin 120. The range of distance between the signal pin 120 and the ground pin 122 can be for example 0.050 inches to 0.500 inches with a resolution of 0.001 inches.

When the distance between the signal pin 120 and the ground pin 122 is adjusted, the robotic system rotates the dual-pin probe 100 to respectively position the signal pin 120 and the ground pin 122 directly adjacent to a signal node and a ground node on the circuit board. With the signal pin 120 and the ground pin 122 properly positioned, the robotic system moves the dual-pin probe 100 so that the signal pin 120 comes into contact with the signal node and the ground pin 122 comes into contact with the ground node. As stated above, the signal pin 120 and the ground pin 122 are preferably spring-loaded to account for mis-alignment of the dual-pin probe 100 or non-linearities on the circuit board. The test probe is activated within the contact tube 110 to measure a signal on the signal node. The robotic system then moves the dual-pin probe 100 to another position on the circuit board to measure another signal.

FIG. 2 shows the dual-pin probe 100 connected to a robot interface 108. The probe body 104 mounts onto the robot interface 108. The robot interface 108 connects to a robotic system (not shown), wherein the robotic system is configured to manipulate the dual-pin probe 100 and the robot interface 108. The probe body 104 includes a pivot actuator 140. The pivot actuator 140 connects to the pivot 132. The pivot actuator 140 has a servomotor 142 and a spring-loaded zero backlash coupling 144. The servomotor 142 is for example a 24 VDC motor using a zero backlash gearhead. The servomotor 142 couples to the pivot 132 through the spring-loaded zero backlash coupling 144. The robot interface 108 includes a probe actuator 150. The probe actuator 150 preferably has a servomotor 152 coupled to an anti-backlash reduction gear 154. The servomotor 152 is for example a 24 VDC motor using a zero backlash gearhead. The reduction gear 154 couples to a gear ring 156, such that the gear ring 156 is keyed onto the probe

body 104.

In operation, the robotic system rotates the pivot 132 by activating the servomotor 142 in the pivot actuator 140. The pivot 132 rotates the pivot arm 130 and adjusts the distance between the signal pin 120 and the ground pin 122. The robotic system rotates the pivot 132 until the ground pin 122 is the desired distance from the signal pin 120. A high-resolution rotary encoder (not shown) coupled to the servomotor 142 and an optical marker pulse preferably provide the robotic system with information on the position of the pivot 132 and/or pivot arm 130. The robotic system then rotates the entire dual-pin probe 100 by activating the servomotor 152 in the probe actuator 150. The servomotor 152 rotates the reduction gear 154. If desired, the reduction gear 154 increases the amount of torque generated by the servomotor 152. The reduction gear 154 turns the gear ring 156 coupled to the probe body 104. The gear ring 156 turns the entire dual-pin probe 100. The probe actuator 150 rotates the dual-pin probe 100 until the signal pin 120 and the ground pin 122 are properly orientated adjacent to a circuit board. A high-resolution rotary encoder (not shown) and an optical marker pulse preferably provide the robotic system with information on the position of the dual-pin probe 100.

The dual-pin probe 100 in FIGS. 1-2 is a significant advance over the prior art. The dual-pin probe 100 automates the testing of circuit boards. Automated testing with the dual-pin probe 100 is fast and accurate, which is an advantage on highly populated boards. The dual-pin probe 100 reduces testing errors and lowers manufacturing costs of circuit boards.

<u>Dual-Pin Probe -- FIGS. 3-4</u>

FIGS. 3-4 depict another embodiment of a dual-pin probe 300 in accord with the present invention. Those skilled in the art will appreciate numerous variations from this example that do not depart from the scope of the invention. Those skilled in the art will also appreciate that various features could be combined to form multiple variations of the invention.

FIG. 3 shows the dual-pin probe 300 with a probe body 304, a probe head 302, a signal pin 320, a ground pin 322, support shafts 334, a pivot arm 330, a pivot 332, and a FET probe 324. The probe body 304 connects to a robot interface

(not shown) of a robotic system (not shown), the robotic system configured to manipulate the dual-pin probe 300. The probe head 302 connects to the probe body 304 through the support shafts 334. The signal pin 320 mounts onto a face 321 of the probe head 302 in a fixed position extending substantially perpendicular to the face 321. The signal pin 320 is for example made from a gold plated material. The FET probe 324 connects to the probe head 302, with a signal lead of the FET probe 324 connecting to the signal pin 320. The FET probe 324 is fastened to the probe head 302 with fasteners such as set screws or clamps. The FET probe 324 can for example be a Tektronics P6245 FET probe.

The pivot 332 extends from the probe body 304 through the probe head 302 to protrude perpendicularly to the face 321 of the probe head 302. The pivot arm 330 mounts on the pivot 332 and is preferably parallel to the face 321 of the probe head 302. The pivot 332 is configured to rotate clockwise or counter-clockwise which in turn rotates the pivot arm 330 in a 360 degree angle. The ground pin 322 mounts onto the pivot arm 330 and protrudes perpendicularly from the pivot arm 330 so that the ground pin 322 and the signal pin 320 are aligned substantially parallel to each other. The ground pin 322 is for example made from a gold plated material. A flexible wire (not shown) connects the ground pin 322 to a ground lead of the FET probe 324. The signal pin 320 and the ground pin 322 are fixed in length to ensure that minimal inductance is introduced into measured signals.

The signal pin 320 and the ground pin 322 are independently retractable. The signal pin 320 is retractable because the support shafts 334 are mounted on precision bearings inside of the probe body 304 to allow for axial movement of the probe head 302. The probe head 302 could retract up to 0.157 inches, for example. The ground pin 322 is retractable because the pivot 332 mounts on precision bearings inside of the probe body 304 and inside the probe head 302 to allow for axial movement of the pivot arm 330. In one example, the pivot arm 330 retracts up to 0.118 inches.

In operation, the robotic system positions the dual-pin probe 300 over a circuit board so that the face 321 of the probe head 302 is substantially parallel to the circuit board. The robotic system adjusts the linear distance between the signal pin 320 and the ground pin 322 by rotating the pivot arm 330. The robotic system increases the distance between the signal pin 320 and the ground pin 322 by

rotating the pivot arm 330 away from the signal pin 320. The robotic system decreases the distance between the signal pin 320 and the ground pin 322 by rotating the pivot arm 330 toward the signal pin 320. The range of distance between the signal pin 320 and the ground pin 322 is typically between about 0.050 inches and 0.750 inches with a resolution of 0.0004 inches.

When the distance between the signal pin 320 and the ground pin 322 is adjusted, the robotic system rotates the dual-pin probe 300 to position the signal pin 320 and the ground pin 322 adjacent to a signal node and a ground node on the circuit board. With the signal pin 320 and the ground pin 322 properly positioned, the robotic system moves the dual-pin probe 300 so that the signal pin 320 comes into contact with the signal node and the ground pin 322 comes into contact with the ground node. As stated above, the signal pin 320 and the ground pin 322 are independently retractable to account for mis-alignment of the dual-pin probe 300 or non-linearities on the circuit board. The FET probe 324 is activated to measure a signal on the signal node. The robotic system then moves the dual-pin probe 300 to another position on the circuit board to measure another signal.

FIG. 4 shows the dual-pin probe 300 connected to a robot interface 308. The probe body 304 mounts onto the robot interface 308. The robot interface 308 connects to a robotic system (not shown), wherein the robotic system is configured to manipulate the dual-pin probe 300 and the robot interface 308. The robot interface 308 includes a pivot actuator 340 and a probe actuator. The pivot actuator 340 connects to the pivot 332 in the dual-pin probe 300. The pivot actuator 340 preferably has a first servomotor and a high-precision bellows coupling. The first servomotor can for example be a 24 VDC motor using a zero backlash gearhead. The first servomotor couples to the pivot 332 through the high-precision bellows coupling. The probe actuator has a second servomotor 352 coupled to an anti-backlash reduction gear 354. The second servomotor 352 can for example be a 24 VDC motor using a zero backlash gearhead. The reduction gear 354 couples to a gear ring 356, such that the gear ring 356 is keyed onto the probe body 304.

In operation, the robotic system rotates the pivot 332 by activating the first servomotor in the pivot actuator 340. The pivot 332 rotates the pivot arm 330 and adjusts the distance between the signal pin 320 and the ground pin 322. The

robotic system rotates the pivot 332 until the ground pin 322 is the desired distance from the signal pin 320. A high-resolution encoder (not shown) coupled to the first servomotor and optical switches (not shown) preferably provide the robotic system with information on the position of the pivot 332 and/or pivot arm 330. The robotic system then rotates the entire dual-pin probe 300 by activating the second servomotor 352 in the probe actuator. The second servomotor 352 rotates the reduction gear 354. If desired, the reduction gear 354 increases the amount of torque generated by the second servomotor 352. The reduction gear 354 turns the gear ring 356 coupled to the probe body 304. The gear ring 356 turns the entire dual-pin probe 300. The robotic system rotates the dual-pin probe 300 until the signal pin 320 and the ground pin 322 are properly orientated adjacent to a circuit board. A high-resolution encoder (not shown) and optical switches (not shown) preferably provide the robotic system with information on the position of the dual-pin probe 300.

The dual-pin probe 300 in FIGS. 3-4 is a significant advance in the art. The dual-pin probe 300 automates the testing of circuit boards. Automated testing with the dual-pin probe 300 is fast and accurate, which is an advantage especially on highly populated boards. The dual-pin probe 300 reduces testing errors and lowers manufacturing costs of circuit boards.

Those skilled in the art will appreciate variations of the above-described embodiments that fall within the scope of the invention. As a result, the invention is not limited to the specific examples and illustrations discussed above, but only by the following claims and their equivalents.

CLAIMS:

We claim:

1. A dual-pin probe configured for manipulation by a robot to facilitate testing of a circuit board, comprising:

a probe body configured for connection to the robot;

a probe head coupled to the probe body, with a distal end configured for positioning adjacent to the circuit board;

a first pin extending from the distal end of the probe head; and

a second pin extending from the distal end of the probe head at a variably controlled distance from the first pin.

2. The dual-pin probe in claim 1, further comprising a test probe coupled to the probe head, wherein a first lead of the test probe connects to the first pin and a second lead on the test probe connects to the second pin.

3. The dual-pin probe in claim 2, wherein the probe head further includes a contact tube configured to house the test probe.

4. The dual-pin probe in claim 1, further comprising a pivot extending from the probe body through the probe head and protruding perpendicularly from the distal end of the probe head.

5. The dual-pin probe in claim 4, wherein the probe body further includes a pivot actuator for rotating the pivot.

6. The dual-pin probe in claim 5, further comprising a pivot arm coupled to the pivot and configured to rotate substantially parallel to the distal end of the probe head.

7. The dual-pin probe in claim 6, wherein the second pin mounts onto the pivot arm.

8. The dual-pin probe in claim 1, wherein the first pin is retractable.

9. The dual-pin probe in claim 1, wherein the second pin is retractable.

10. The dual-pin probe in claim 1, wherein the first pin is substantially parallel to the second pin.

11. The dual-pin probe in claim 1, wherein the first pin and the second pin are fixed in length.

12. The dual-pin probe in claim 1, wherein the probe head is insulated.

13. The dual-pin probe in claim 1, wherein the probe head is further configured with a low capacitance.

14. The dual-pin probe in claim 1, wherein the first pin is a signal pin and the second pin is a ground pin.

15. An automated method of testing a circuit board, comprising the steps of:

determining first and second test nodes on the circuit board;

determining a linear distance between and an orientation of the first and second test nodes;

varying distance between a first pin and a second pin of a probe head to match the linear distance;

rotating the first pin and the second pin to position the first pin adjacent to the first test node and the second pin adjacent to the second test node;

contacting the first pin to the first node; and

contacting the second pin to the second node.

16. The method in claim 15, further comprising connecting a first lead of a test probe to the first pin and a second lead of the test probe to the second pin.

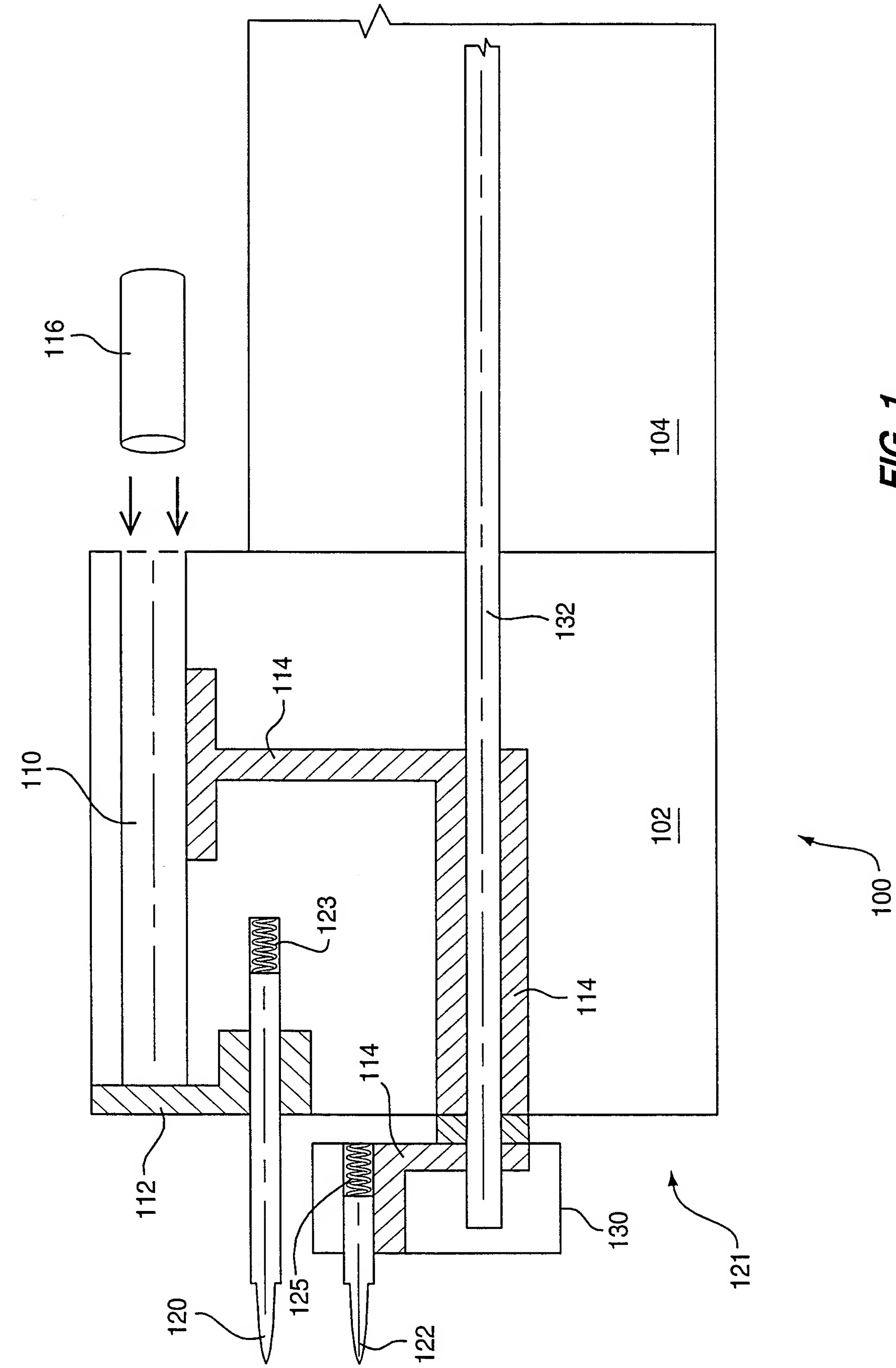

FIG. 1

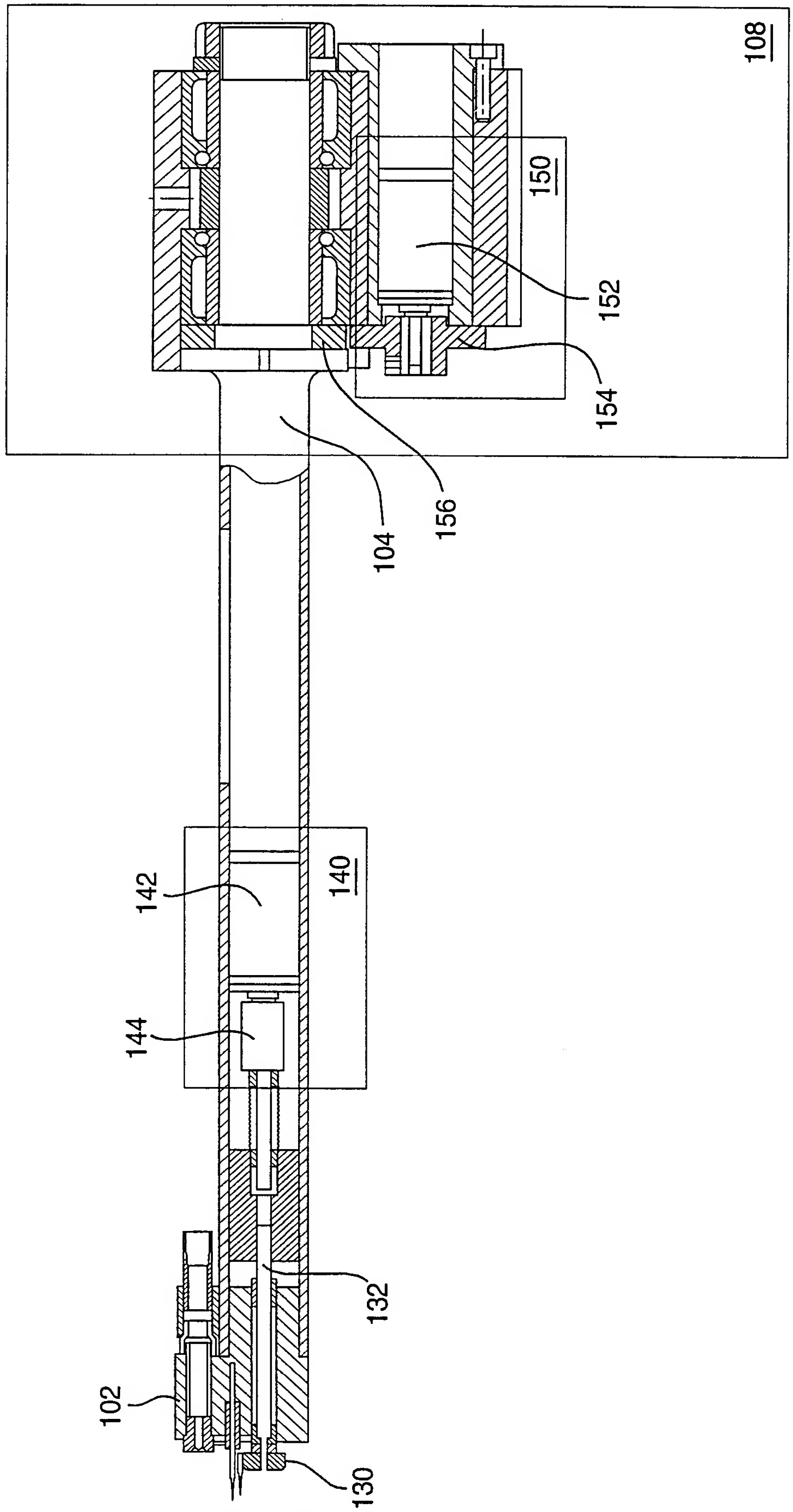

FIG. 2

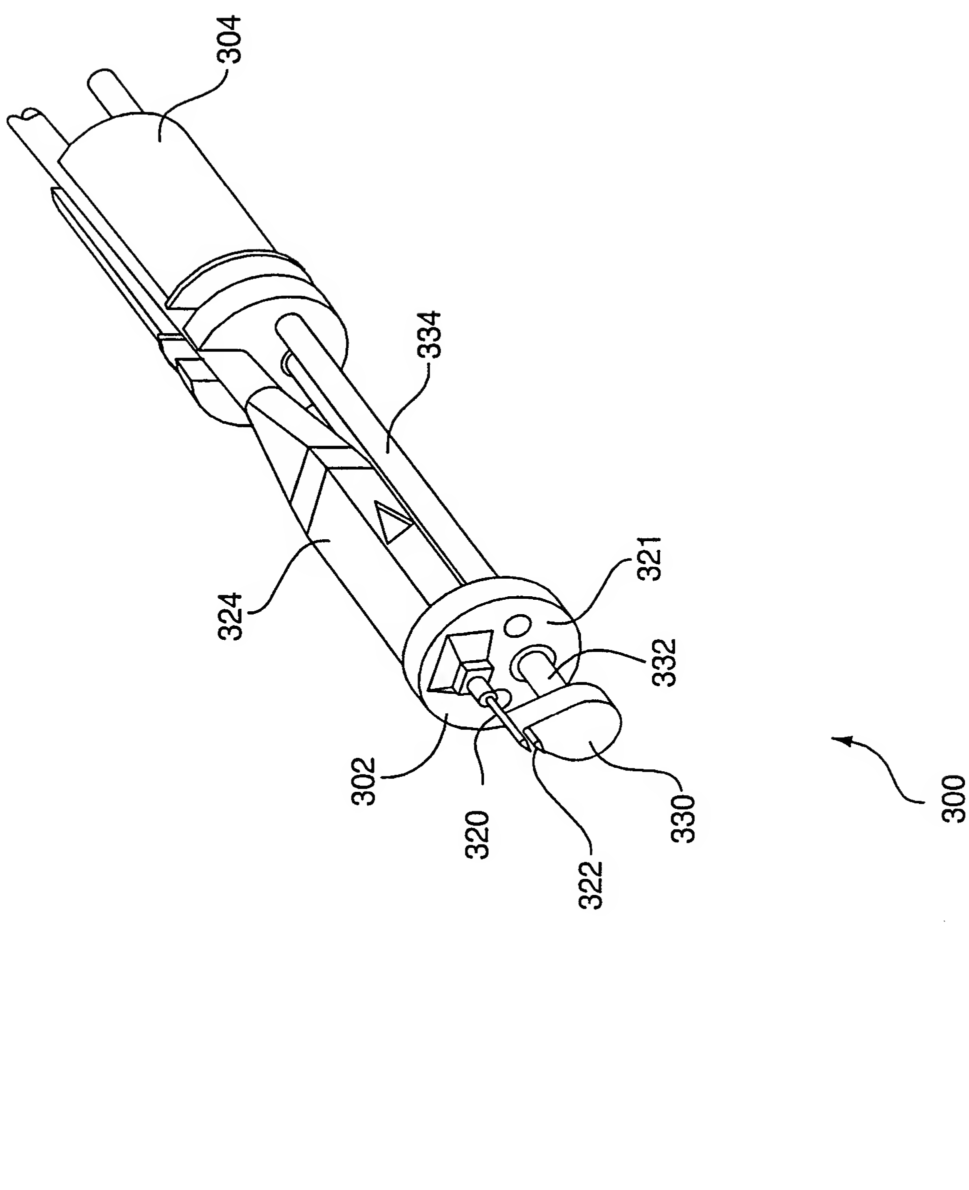

FIG. 3

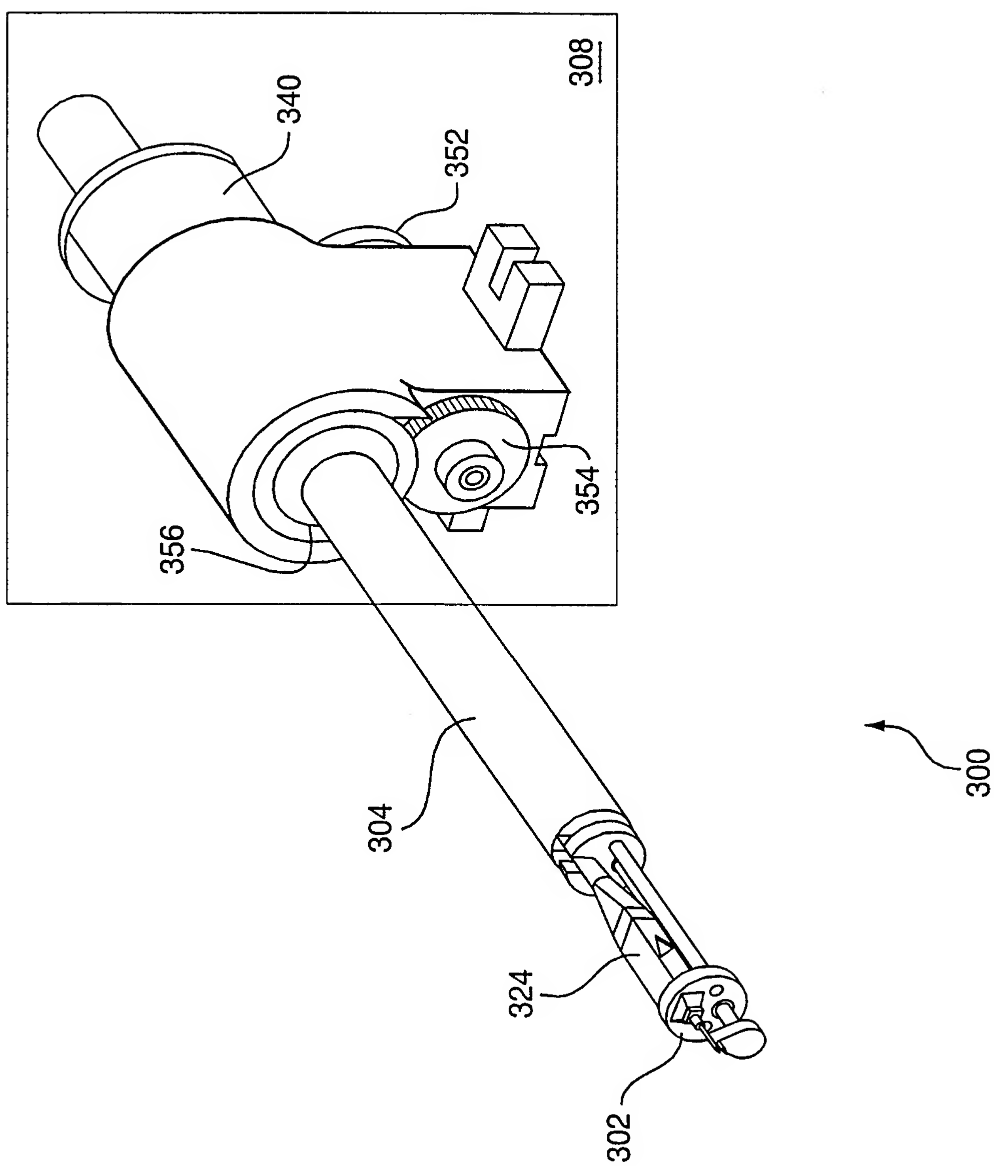

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/31236

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01R1/073

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01R H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2000	02/05/2000

Name and mailing address of the ISA	Authorized officer
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PCT/US 99/31236

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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